US009166300B2

(12) United States Patent
Taura

(10) **Patent No.: US 9,166,300 B2**
(45) **Date of Patent: Oct. 20, 2015**

(54) **SLOT ANTENNA**

(75) Inventor: **Toru Taura**, Tokyo (JP)

(73) Assignee: **NEC Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 219 days.

(21) Appl. No.: **13/995,929**

(22) PCT Filed: **Oct. 27, 2011**

(86) PCT No.: **PCT/JP2011/006008**

§ 371 (c)(1), (2), (4) Date: **Jun. 19, 2013**

(87) PCT Pub. No.: **WO2012/107976**

PCT Pub. Date: **Aug. 16, 2012**

(65) **Prior Publication Data**

US 2013/0271333 A1 Oct. 17, 2013

(30) **Foreign Application Priority Data**

Feb. 9, 2011 (JP) 2011-026066

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 5/357 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/106*** (2013.01); ***H01Q 5/357*** (2015.01); ***H01Q 13/10*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 13/106
USPC 343/767
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0008146	A1	1/2004	Ikegaya et al.	
2005/0012674	A1*	1/2005	Takei	343/767
2006/0050002	A1*	3/2006	Wang et al.	343/767
2008/0272972	A1*	11/2008	Kanno et al.	343/767
2010/0231477	A1*	9/2010	Kuramoto et al.	343/795

FOREIGN PATENT DOCUMENTS

CN	101075699	A	11/2007
CN	201075403	Y	6/2008
JP	5-110332		4/1993
JP	2004-048119	A	2/2004

(Continued)

OTHER PUBLICATIONS

International Search Report (ISR) (PCT Form PCT/ISA/210), in PCT/JP2011/006008, dated Jan. 31, 2012.

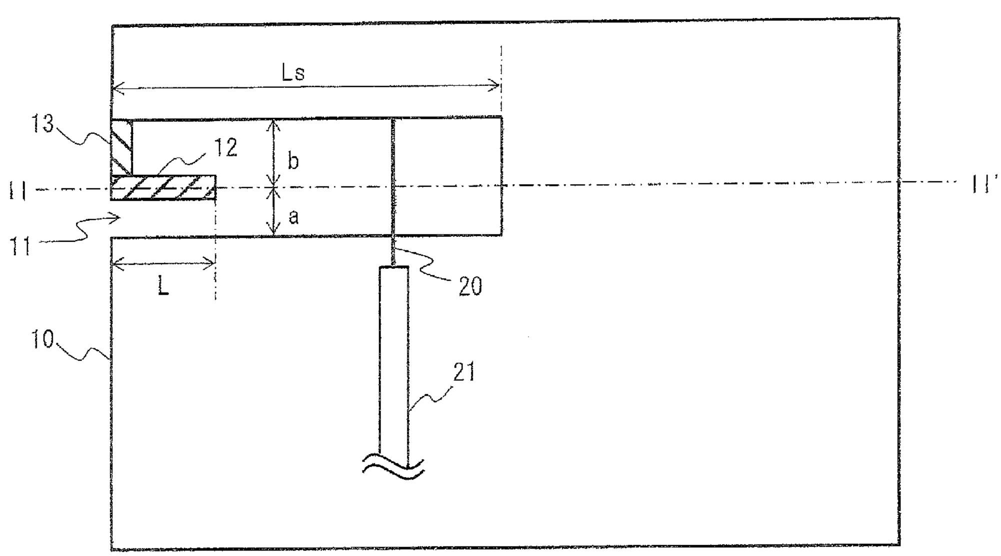
(Continued)

Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — McGinn IP Law Group, PLLC

(57) **ABSTRACT**

A slot antenna includes a dielectric substrate, a conductor surface provided on one of surfaces of the dielectric substrate, a slot formed by making a cut in the conductor surface, one end of the cut forming an opened end on an edge of the conductor surface, and a stub formed inside the slot, the stub being connected to one of opposing sides of the slot by using a connection part, in which the stub is formed in such a manner that a length of the connection part becomes longer than a distance between a side opposing to the side connected to the connection part and the stub.

15 Claims, 11 Drawing Sheets



(56) **References Cited**

FOREIGN PATENT DOCUMENTS

JP	2005-039394	A	2/2005
WO	WO 2007/138959	A1	12/2007

OTHER PUBLICATIONS

Chinese Office Action dated Aug. 13, 2014 with an English Translation thereof.

* cited by examiner

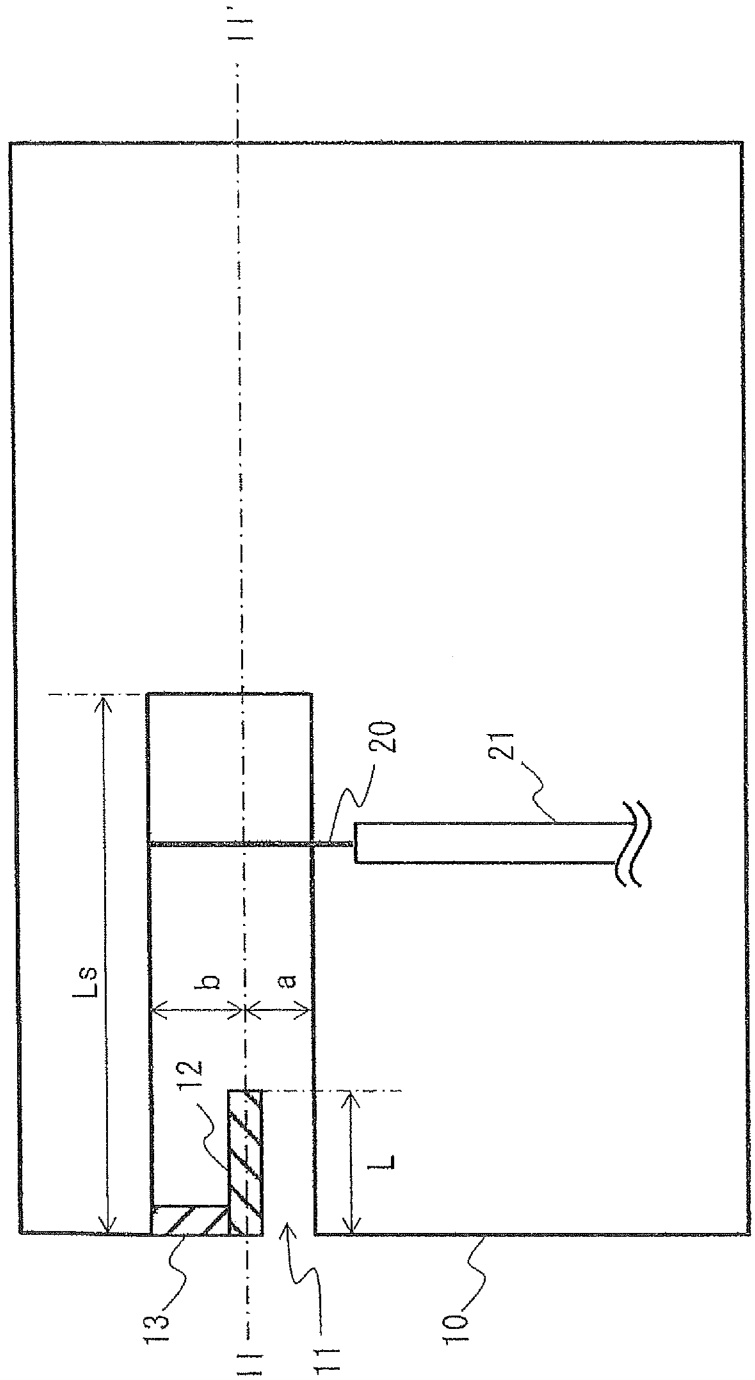


Fig. 1

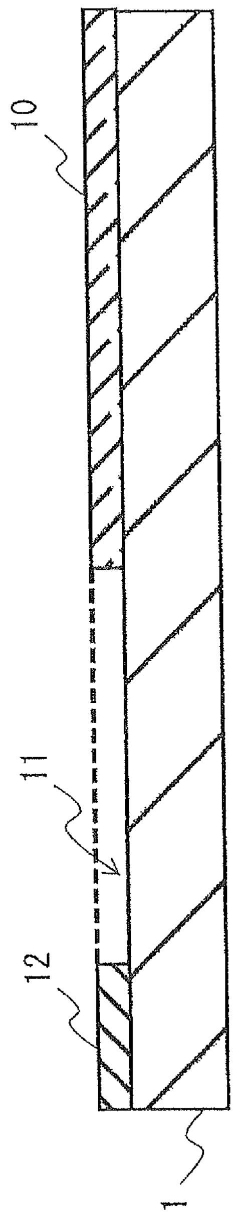
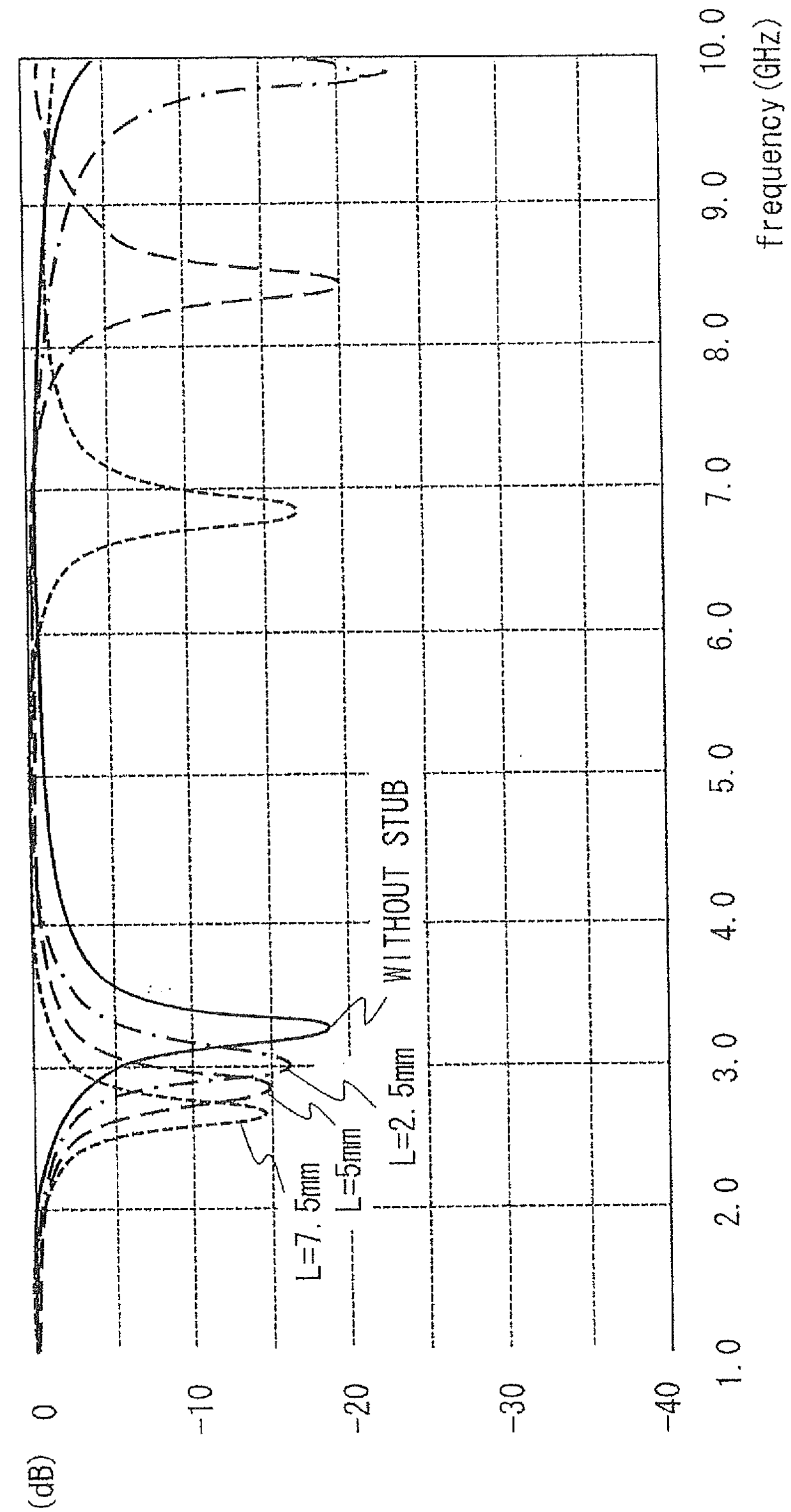


Fig. 2



(dB)
0
-10
-20
-30
-40
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
frequency (GHz)
L=7. 5mm
L=5mm
L=2. 5mm
WITHOUT STUB

Fig. 3

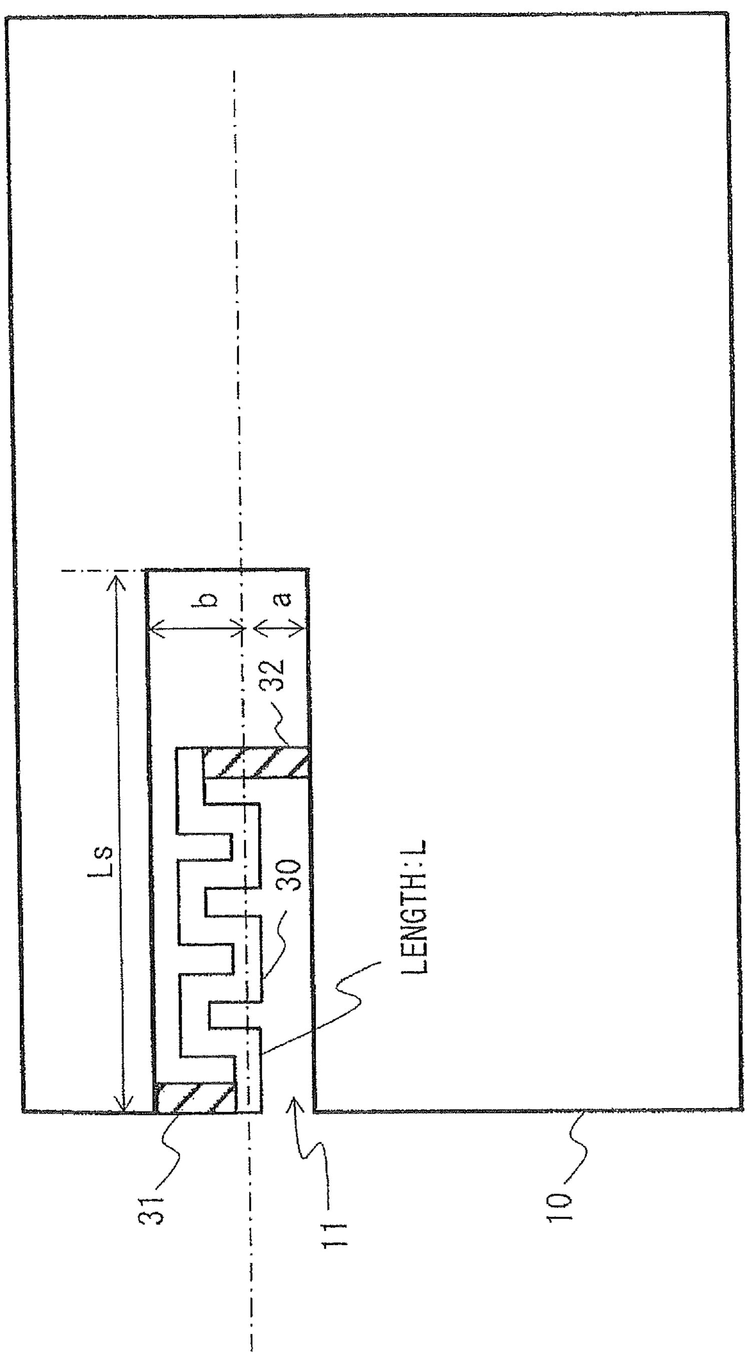


Fig. 4

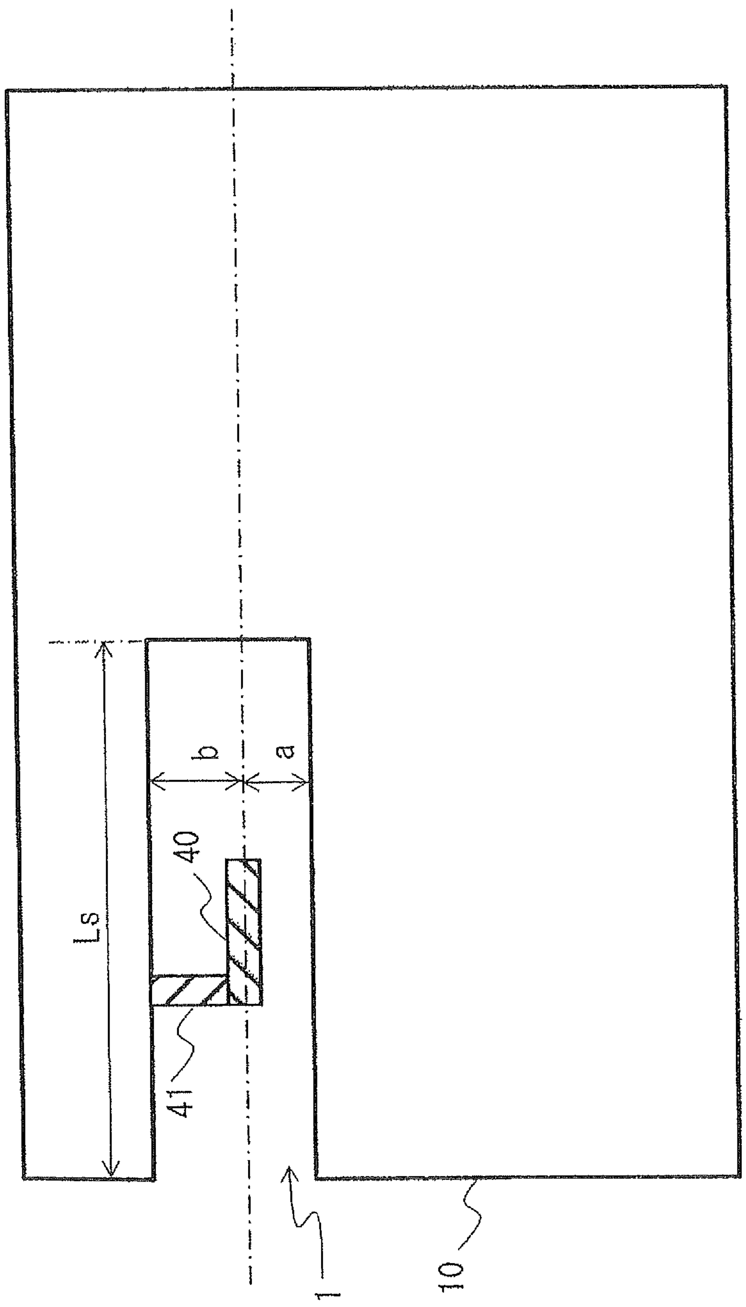


Fig. 5

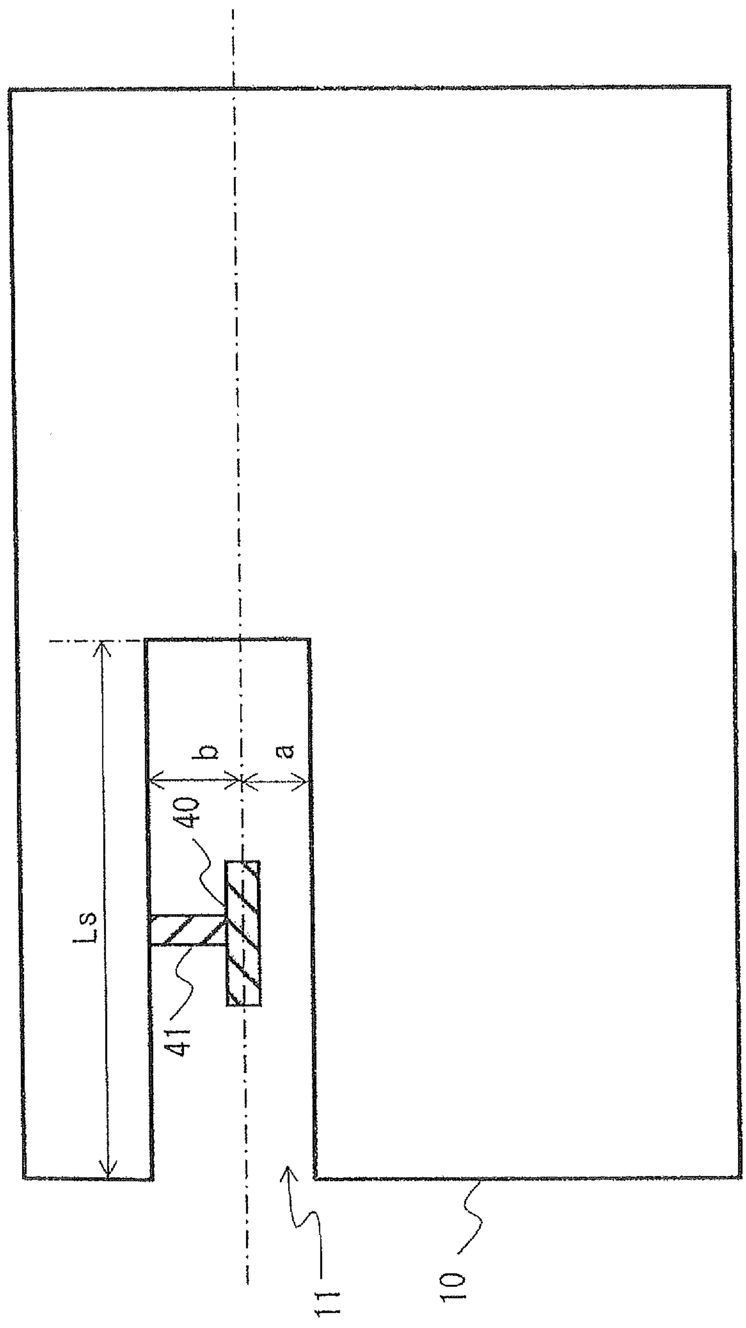


Fig. 6

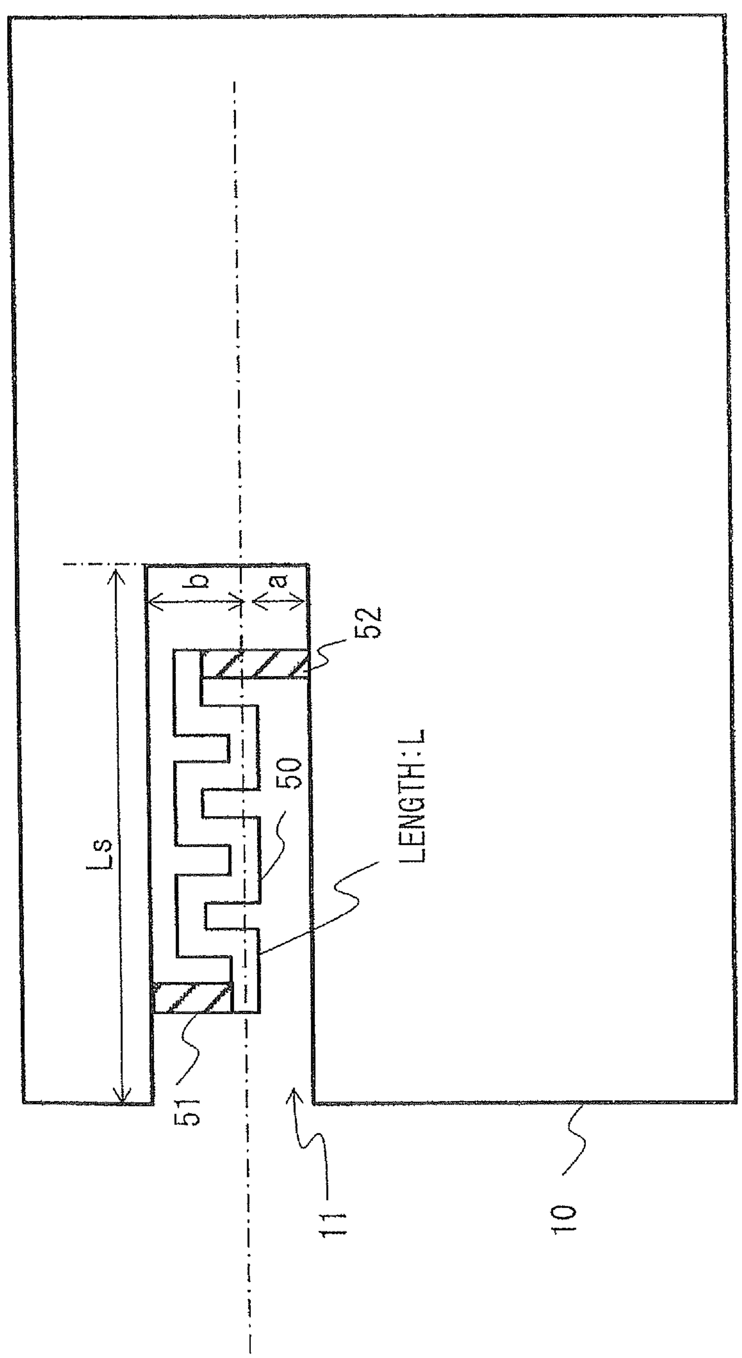


Fig. 7

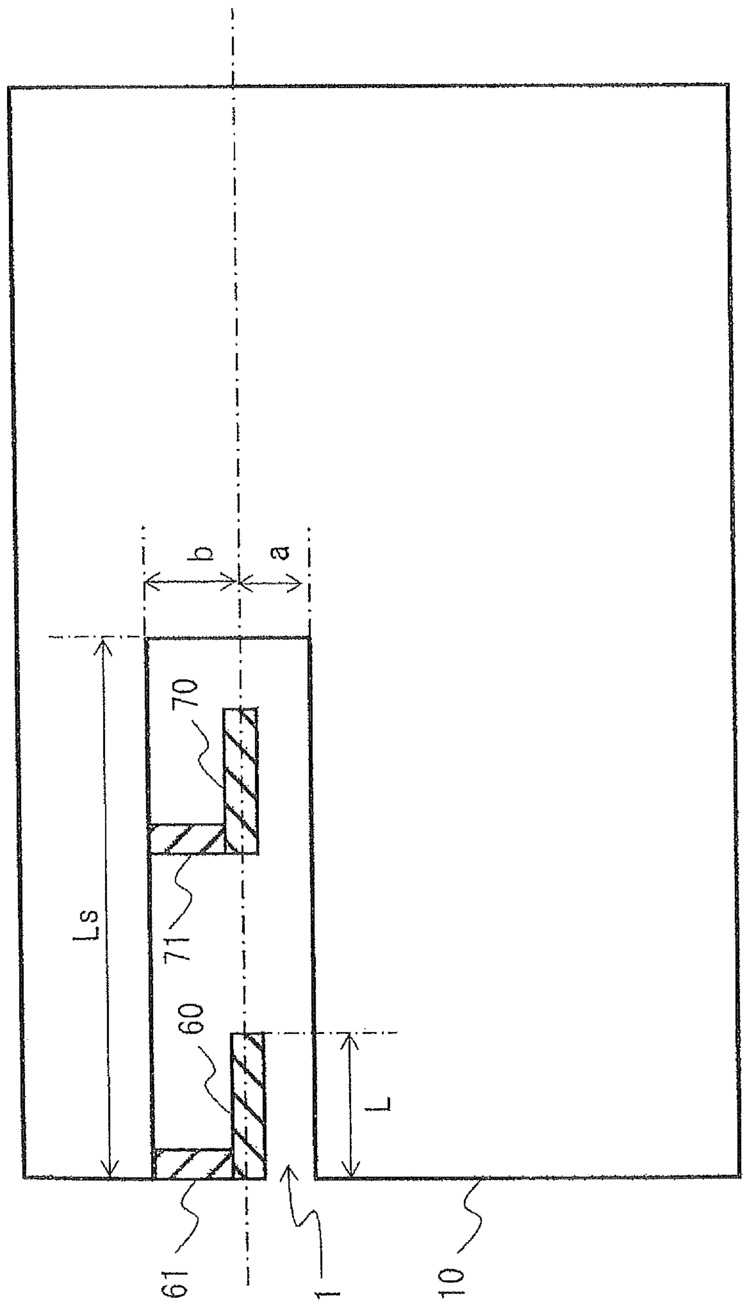


Fig. 8

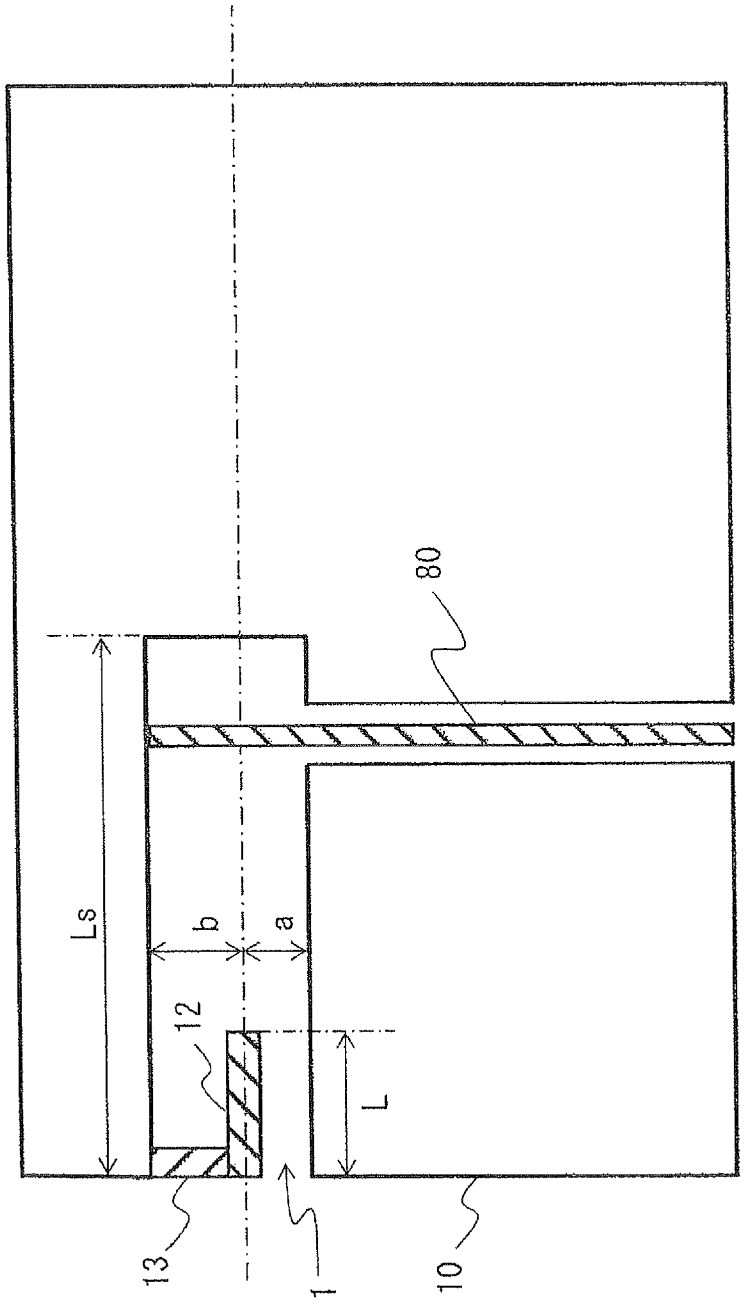


Fig. 9

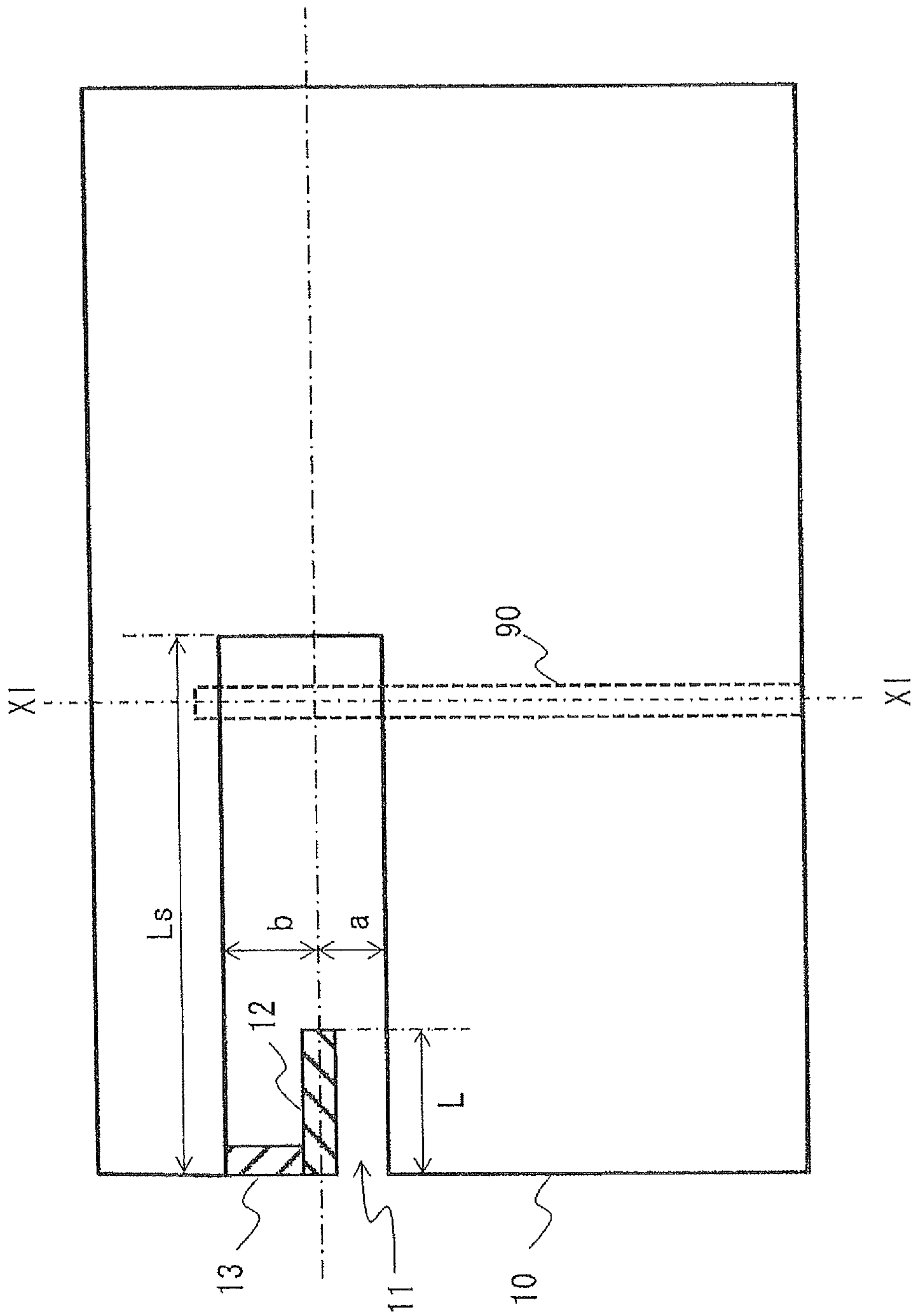


Fig. 10

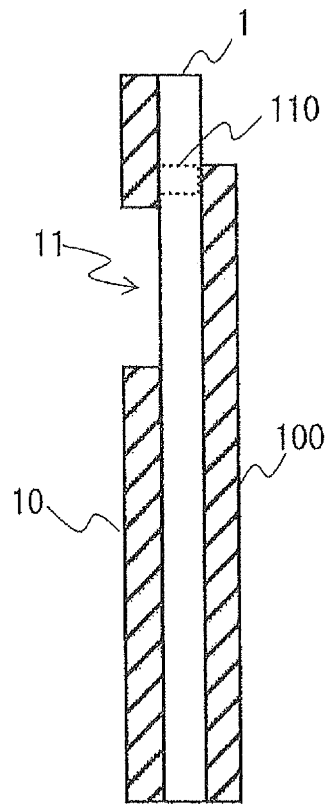


Fig. 11

SLOT ANTENNA

TECHNICAL FIELD

The present invention relates to a slot antenna, in particular, a slot antenna whose resonance frequency is adjusted by using a stub.

BACKGROUND ART

In general, the length of a slot antenna disposed on a dielectric substrate needs to be one quarter of the wavelength of the used frequency. For example, when the frequency is 800 MHz, the length of the slot antenna is about 90 mm and thus is too large to be applied to a portable radio terminal in which the packaging space is severely limited.

As a technique for reducing an antenna in size, Patent literature 1 discloses a method for forming a capacitor at a slot end. The configuration for forming a capacitor at a slot end disclosed in Patent literature 1 makes it possible to shift the resonance frequency of the antenna widely by a small capacitance. For example, Patent literature 1 discloses a structure for forming a capacitor at a slot end by using a conductive projection. Further, Patent literature 1 discloses a structure for forming a capacitor at a slot end by disposing a chip capacitor at the slot end.

Further, Patent literature 2 discloses a configuration for adding an additional radiation conductor in a part of a radiation conductor that forms a slot inside a slot in order to dispose an antenna inside the housing of a portable terminal or the like and to make it possible to transmit/receive radio waves in a plurality of frequency bands by using one antenna.

CITATION LIST

Patent Literature

Patent literature 1: Japanese Unexamined Patent Application Publication. No. 5-110332

Patent literature 2: Japanese Unexamined Patent Application Publication. No. 2004-48119

SUMMARY OF INVENTION

Technical Problem

However, in the configuration for forming a capacitor at a slot end disclosed in Patent literature 1, the resonance frequency of the antenna could be widely changed due to a slight error in the loaded capacitance. Therefore, it is necessary to elaborately create a loaded capacitance with high accuracy. Specifically, in the configuration for forming a capacitor by using a conductive projection, there is a problem that the resonance frequency of the antenna could be deviated due to the variations in the mass production such as thickness variations of the dielectric substrate and relative dielectric constant variations. Further, in the configuration using a chip capacitor, there is a problem that the resonance frequency of the antenna could be deviated due to the capacitance variations of the chip capacitor itself.

Further, in the slot antenna disclosed in Patent literature 2, the specific shape and the like of the radiation conductor added inside the slot are not clearly described. Therefore, it is unclear whether or not the slot antenna can be actually reduced in size by adding the radiation conductor inside the slot.

To solve the problems like this, an object of the present invention is to provide a slot antenna capable of, when the slot antenna is reduced in size, adjusting the resonance frequency with high accuracy.

Solution to Problem

A slot antenna according to a first aspect of the present invention includes: a dielectric substrate; a conductor surface provided on one of surfaces of the dielectric substrate; a slot formed by making a cut in the conductor surface, one end of the cut forming an opened end on an edge of the conductor surface; and a stub formed inside the slot, the stub being connected to one of opposing sides of the slot by using a connection part, in which the stub is formed in such a manner that a length of the connection part becomes longer than a distance between a side opposing to the side connected to the connection part and the stub.

Advantageous Effects of Invention

According to the present invention, it is possible to provide a slot antenna capable of, when the slot antenna is reduced in size, adjusting the resonance frequency with high accuracy.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a configuration diagram of a slot antenna according to a first exemplary embodiment;

FIG. **2** is a cross section of a slot antenna according to a first exemplary embodiment;

FIG. **3** shows a calculation example of an impedance characteristic of a slot antenna device according to a first exemplary embodiment;

FIG. **4** is a configuration diagram of a slot antenna according to a second exemplary embodiment;

FIG. **5** is a configuration diagram of a slot antenna according to a third exemplary embodiment;

FIG. **6** is a configuration diagram of a slot antenna according to a third exemplary embodiment;

FIG. **7** is a configuration diagram of a slot antenna according to a fourth exemplary embodiment;

FIG. **8** is a configuration diagram of a slot antenna according to a fifth exemplary embodiment;

FIG. **9** is a configuration diagram of a slot antenna according to a sixth exemplary embodiment;

FIG. **10** is a configuration diagram of a slot antenna according to a sixth exemplary embodiment; and

FIG. **11** is a configuration diagram of a slot antenna according to a sixth exemplary embodiment.

DESCRIPTION OF EMBODIMENTS

First Exemplary Embodiment

Exemplary embodiments according to the present invention are explained hereinafter with reference to the drawings. FIG. **1** shows a stub disposed in a slot in a conductor surface of a slot antenna device according to a first exemplary embodiment of the present invention. FIG. **2** shows a general configuration of the slot antenna device according to the first exemplary embodiment of the present invention, and is a cross section taken along a line II-II' in FIG. **1**.

The slot antenna device includes a plate-like dielectric substrate **1** made of dielectric, a conductor surface **10** provided on one of the surfaces (e.g., top surface) of the dielectric substrate **1**, a slot **11** formed by making a cut in the conductor surface **10**, and a stub **12** formed inside the slot **11**. Further, one end of the cut forms an opened end on the edge of the conductor surface **10**, and the stub **12** is connected to one of opposing sides of the slot by using a connection part **13**. Each of an external conductor of a feeder **21** and a feeding part **20**, i.e., an internal conductor of the feeder **21** is connected to the conductor surface **10** on both sides of the slot **11** in such a manner that they are connected across the slot **11**. A radio circuit (not shown) feeds electricity to the slot **11** through the feeder **21** and the feeding part **20**.

The slot **11** is formed in such a manner that one end is an opened end and the other end is a short-circuited end, and the length of the slot **11** is represented by Ls. When a wavelength corresponding to a used frequency is represented by λ, the slot **11** resonates at a frequency at which the length Ls is equal to $\lambda/4$. The slot **11** has a straight-line shape, and one of the opposing sides of the slot **11** is connected to the stub **12** by using the connection part **13**.

The stub **12** is a plate-like member having a narrow straight-line shape. The length L of the stub **12** (stub length) is adjusted so that, when a wavelength corresponding to a used frequency is represented by λ, the relation "$L<\lambda/4$" is satisfied. Further, the width of the stub **12** is substantially small in comparison to the stub length L. One end of the stub **12** is connected to one of the opposing sides of the slot **11** having a straight-line shape through the connection part **13**. The other end of the stub **12** forms an opened end. Therefore, the stub **12** forms an opened-end type stub. FIG. **1** shows an example in which the stub **12** is connected near the opened end of the slot **11**. All of the conductor surface **10**, the stub **12**, and the connection part **13** may be conductors that are formed by using similar material.

The slot antenna explained above with reference to FIGS. **1** and **2** is configured so that the stub length L of the stub **12** disposed at the opened end of the slot **11** satisfies the relation "$L<\lambda/4$". This configuration is equivalent to a state where a capacitance is loaded at the opened end of the slot **11**, and the resonance frequency of the slot antenna is shifted to the low frequency side. As a result, it is possible to reduce the slot in size. Note that the value of the capacitance generated by the stub **12** is determined mainly by the stub length L. Therefore, the capacitance value generated by the stub **12** is hardly affected by the thickness of the dielectric substrate **1** and the relative dielectric constant of the dielectric forming the dielectric substrate **1**.

Note that when a distance between the stub **12** and the side of the slot **11** that is not connected to the connection part **13** is represented by "a" and the length of the connection part **13** is represented by "b", the stub **12** needs to be disposed in such a manner that the distance "a" becomes shorter than the length "b". By disposing the stub **12** in the above-described position and adjusting the stub length L to satisfy the relation "$L<\lambda/4$" as described above, a necessary capacitance for shifting the resonance frequency to the low frequency side is added in the slot **11**. Further, the amount of this shift can be controlled by adjusting the stub length L.

Next, a calculation example of an impedance characteristic of the slot antenna device according to this first exemplary embodiment is explained with reference to FIG. **3**. When the stub length L of the opened-end type stub **12** shown in FIG. **1** is changed over a range between 0 mm and 7.5 mm, the impedance characteristic of the slot antenna device is changed as shown in FIG. **3**. That is, by increasing the stub length L, the resonance frequency is shifted to the low frequency side. In this calculation example, the distance "a" is sufficiently shorter than the length "b". That is, the calculation was carried out on the condition that "a=0.25 mm" and "b=1.25 mm".

By changing the stub length L and thereby controlling the capacitance to be loaded at the opened end of the slot **11** in this manner, it is possible to adjust the resonance frequency of the slot antenna device with high accuracy without changing the size of the slot **11**. That is, it is possible to achieve a desired antenna resonance frequency by using a slot **11** having a smaller size.

As explained above, the slot antenna device according to the first exemplary embodiment of the present invention has such a configuration that the capacitance to be loaded in the slot antenna device is controlled by adjusting the stub length L of the stub **12**. Therefore, it is possible to reduce the effect to the resonance frequency of a slot antenna device resulting from the variations in the thickness of the dielectric substrate **1** and the variations in the relative dielectric constant of the dielectric and thereby to adjust the resonance frequency with high accuracy.

Further, since the conductor pattern(s) of the stub **12** and the connection part **13** can be formed by using an ordinary printed-circuit board manufacturing process, the variations in the stub length L can be kept at a very small level. As a result, the resonance frequency of the slot antenna device can be controlled with high accuracy.

Further, the slot antenna device does not need to use any chip capacitor to control the capacitance. Therefore, the cost of the slot antenna device can be reduced because of the smaller number of necessary components.

Second Exemplary Embodiment

FIG. **4** shows a stub disposed in a slot in a conductor surface of a slot antenna device according to a second exemplary embodiment of the present invention. In the slot antenna device according to this second exemplary embodiment, one end of a stub **30** is connected to the conductor surface **10** near the opened end of the slot **11** through a connection part **31**. Further, the other end of the stub **30** is connected to the side opposing to the side connected to the connection part **31** through a connection part **32**. The stub **30** shown in FIG. **4** is a short-circuited-end type stub in which the other end is short-circuited to the conductor surface **10**. Further, the stub **30** shown in FIG. **4** is formed in a meandering shape. The stub **30** formed in a meandering shape is configured so that the stub length L satisfies a relation "$\lambda/4<L<\lambda/2$". The other configuration of the slot antenna device according to this second exemplary embodiment is roughly the same as that of the slot antenna device according to the above-described first exemplary embodiment. Therefore, the same symbols are assigned to the same parts and their detailed explanation is omitted. Further, assume that a feeder and a feeding part are also connected in a similar manner to those of the first exemplary embodiment.

When the slot antenna device having the above-described configuration is configured so that the stub length L of the stub **30** disposed inside the slot **11** satisfies the relation "$\lambda/4<L<\lambda/2$", it becomes equivalent to a state where a capacitance is loaded at the opened end of the slot **11**. Therefore, the resonance frequency of the slot antenna device is shifted to the low frequency side.

Further, assume that the length of the connection part **31** connected to the opened end of the slot **11** is "b" and that the shortest distance between the side opposing to the side connected to the connection part **31** and the stub **30** is "a". In this case, the stub **30** is disposed so that the distance "a" becomes smaller than the length "b". By disposing the stub **30** in the above-described position and adjusting the stub length L to satisfy the relation "$\lambda/4<L<\lambda/2$" as described above, a necessary capacitance for shifting the resonance frequency to the low frequency side is added in the slot **11**. Further, the amount of this shift can be controlled by adjusting the stub length L.

Therefore, similarly to the slot antenna device according to the above-described first exemplary embodiment, it is also possible in the slot antenna device according to this second exemplary embodiment to adjust the resonance frequency of the slot antenna device with high accuracy by changing the stub length L and thereby controlling the capacitance to be loaded at the opened end of the slot **11** without changing the size of the slot **11**. That is, it is possible to achieve a desired resonance frequency by using a slot **11** having a smaller size.

Further, similarly to the slot antenna device according to the above-described first exemplary embodiment, the capacitance value generated by the stub **30** in the slot antenna device according to this second exemplary embodiment is determined by the stub length L and thus hardly affected by the thickness of the dielectric substrate **1** and the relative dielectric constant of the dielectric. Further, the conductor pattern(s) that forms the stub **30** and the connection parts **31** and **32** can be formed by using an ordinary printed-circuit board manufacturing process. Therefore, the variations in the stub length L can be kept at a very small level. That is, it is possible to reduce the variations in the capacitance generated by the stub **30** and thereby to control the resonance frequency with high accuracy.

Note that the shape of the stub **30** is not limited to the meandering shape. That is, the stub **30** may have a spiral shape, a folded shape, an irregularly-meandering shape, or the like.

Third Exemplary Embodiment

FIG. **5** shows a stub disposed in a slot in a conductor surface of a slot antenna device according to a third exemplary embodiment of the present invention. In the slot antenna device according to this third exemplary embodiment, a stub **40** is connected to the dielectric substrate **1** through a connection part **41** in such a manner that the stub **40** is positioned on the inner side with respect to the slot opened end. The configuration other than the stub **40** and the connection part **41** is similar to that of the slot antenna according to the first exemplary embodiment. In the slot antenna device according to the third exemplary embodiment, the shift amount of the antenna resonance frequency to the low frequency side decreases as the distance between the stub position and the opened end of the slot **11** increases. The stub position of the slot antenna device according to this third exemplary embodiment is adjusted based on this fact, and this enables a fine adjustment of the resonance frequency.

Further, although the stub **40** and the connection part **41** shown in FIG. **5** have an L-shape, the shape of the stub **40** and the connection part **41** is not limited to this shape. Similarly, the shape of the stub **12** and the connection part **13** shown in FIG. **1** is not limited to an L-shape. The stub **40** and the connection part **41** may have any shape, provided that one end of the stub **40** is an opened end and the other end is connected to the dielectric substrate **1** through the connection part **41**. For example, as shown in FIG. **6**, the stub **40** and the connection part **41** may have a T-shape. Further, although the opened end of the stub **40** is located on the inner side of the slot **11** with respect to the connection part **41** in FIG. **5**, the stub **40** and the connection part **41** may have such a shape that the opened end of the stub **40** is located on the opened-end side of the slot **11** with respect to the connection part **41**. Further, the stub **40** may have a meandering shape, a folded shape, or an irregularly-meandering shape.

Fourth Exemplary Embodiment

FIG. **7** shows a stub disposed in a slot in a conductor surface of a slot antenna device according to a fourth exemplary embodiment of the present invention. In the slot antenna device according to this fourth exemplary embodiment, a stub **50** formed in a meandering shape is connected to the dielectric substrate **1** through connection parts **51** and **52** in such a manner that the stub **50** is located on the inner side with respect to the slot opened end. The configuration other than the stub **50** and the connection parts **51** and **52** is similar to that of the slot antenna according to the second exemplary embodiment. In the slot antenna device according to the fourth exemplary embodiment, the shift amount of the antenna resonance frequency to the low frequency side decreases as the distance between the stub position and the opened end of the slot **11** increases. By this feature, in the slot antenna device according to this fourth exemplary embodiment, the stub position adjustment enables a fine adjustment of the resonance frequency.

Further, although the stub **50** and the connection parts **51** and **52** shown in FIG. **7** have a meandering shape, the shape of the stub **50** and the connection parts **51** and **52** is not limited to this shape. The connection parts **51** and **52** may have any shape, provided that the connection part **51** is connected to one side of the slot **11** and the connection part **52** is connected to the side opposing to the side connected to the connection part **51**. For example, the stub **50** may have a folded shape or an irregularly-meandering shape.

Fifth Exemplary Embodiment

FIG. **8** shows a stub disposed in a slot in a conductor surface of a slot antenna device according to a fifth exemplary embodiment of the present invention. In the slot antenna device according to this exemplary embodiment, an opened-end type stub **70** is further disposed inside the slot **11** in addition to an opened-end type stub **60** disposed at the opened end of the slot **11**. Further, the stub **70**, which is disposed inside the slot **11**, is disposed at a position $\lambda/2$ away from the opened end of the slot **11**.

The electric field of a slot antenna in a resonance frequency **1** corresponding to a state where the slot length is one quarter of the wavelength has such a standing wave distribution that the electric field at the opened end of the slot **11** becomes an anti-node and the electric field at the short-circuited end side becomes a node. In contrast to this, the electric field of a slot antenna in a resonance frequency **2** corresponding to a state where the slot length is three quarters of the wavelength has such a standing wave distribution that the electric fields at the opened end of the slot **11** and a position $\lambda/2$ away from the opened end of the slot **11** become an anti-node and the electric fields at a position $\lambda/4$ away from the opened end of the slot **11** and a position $3\lambda/4$ away from the opened end become a node.

Note that when the stub **60** and the stub **70** are disposed at the opened end of the slot **11** and a position $\lambda/2$ away from the opened end of the slot **11**, respectively, at which the standing wave distribution becomes an anti-node, the following effects are obtained. Both of the resonance frequencies **1** and **2** can be changed by adjusting the stub length of the stub **60** disposed at the opened end of the slot **11**. Further, only the resonance frequency **2** can be changed by adjusting the stub length of the stub **70** disposed at the position λ/2 away from the opened end of the slot **11**.

Therefore, in this fifth exemplary embodiment, firstly, the resonance frequency **1** is adjusted to a desired resonance frequency by controlling the stub length of the stub **60** disposed at the opened end of the slot **11**. Then, the resonance frequency **2** is adjusted to a desired resonance frequency by controlling the stub length of the stub **70** disposed at the position λ/2 away from the opened end of the slot **11**. Since the resonance frequency(s) of the slot antenna device according to the fifth exemplary embodiment can be adjusted in this manner, it is possible to produce multiple resonances by using only one slot without changing the size of the slot length. As a result, it is possible to achieve a substantial reduction of the antenna in size.

Further, it is possible to independently adjust a plurality of resonance frequencies by disposing a plurality of stubs at appropriate positions and independently controlling each stub length. As a result, it is possible to curtail the frequency adjustment process.

Further, although an example in which two stubs are disposed is explained in this fifth exemplary embodiment, the number of stubs is not limited to two. Further, although an example in which opened-end type stubs are used is explained in this fifth exemplary embodiment, a plurality of short-circuited-end type stubs may be disposed.

Sixth Exemplary Embodiment

FIG. **9** shows a configuration of a feeder of a slot antenna device according to a sixth exemplary embodiment of the present invention. The slot antenna device according to this sixth exemplary embodiment has a similar configuration to that of the slot antenna device according to the first exemplary embodiment except that a coplanar type feeder **80** is used for the feeder of the slot antenna device according to the first exemplary embodiment. Further, FIG. **10** shows a slot antenna device in which a micro-strip type feeder **90** is used for the feeder. FIG. **11** is a cross section of the slot antenna device shown in FIG. **10**, taken along a line XI-XI in FIG. **10**. In the slot antenna device according to FIGS. **10** and **11**, a conductor surface **10** is formed on one of the surfaces of the dielectric substrate **1** and a conductor surface **100** is formed on the other surface. Further, a through hole **110** is formed in the dielectric substrate **1** and the conductor surface **10** and the conductor surface **100** are electrically connected through the through hole **110**.

In the slot antenna shown in this sixth exemplary embodiment, both the feeder and the radio circuit can be formed on one printed-circuit board. Therefore, it is possible to reduce the packaging space. Further, since there is no need to wire the feeder cable, it is possible to prevent electromagnetic interference between the feeder cable and other circuits/functional components, undesired radiation, radio performance deterioration due to the power loss, or the like caused by the feeder cable. Further, as for the cost, it is possible to reduce the cost in the antenna production.

Note that the present invention is not limited to the above-described exemplary embodiments, and modifications can be made as appropriate without departing the spirit and scope of the present invention.

Although the present invention is explained above with reference to exemplary embodiments, the present invention is not limited to the description above. Various modifications that can be understood by those skilled in the art can be made to the configuration and details of the present invention within the scope of the invention.

This application is based upon and claims the benefit of priority from Japanese patent application No. 2011-026066, filed on Feb. 9, 2011, the disclosure of which is incorporated herein in its entirety by reference.

REFERENCE SIGNS LIST

1 DIELECTRIC SUBSTRATE
10 CONDUCTOR SURFACE
11 SLOT
12 STUB
13 CONNECTION PART
20 FEEDING PART
21 FEEDER
30 STUB
31 CONNECTION PART
32 CONNECTION PART
80 COPLANAR TYPE FEEDER
90 MICRO-STRIP TYPE FEEDER
100 CONDUCTOR SURFACE
110 THROUGH HOLE

The invention claimed is:

1. A slot antenna comprising:
- a dielectric substrate;
- a conductor surface provided on one of surfaces of the dielectric substrate;
- a rectangular-shaped slot formed by making a cut in the conductor surface, and including first and second long sides, and a short side forming an opened end on an edge of the conductor surface;
- a stub formed inside the slot and connected to a connection part, the connection part being connected perpendicularly to the first long side of the slot; and
- a feeder connected to the conductor surface on the first and second long sides of the slot such that the feeder is connected across the slot,
- wherein the connection part is formed such that a length of the connection part becomes longer than a perpendicular distance between the second long side and the stub.

2. The slot antenna according to claim **1**, wherein the stub comprises an opened-end type stub, one end of the stub being connected to the first long side of the slot by using the connection part, and another end of the stub being in an opened state, and
- a length of the stub is shorter than one quarter of a wavelength corresponding to a used frequency.

3. The slot antenna according to claim **2**, wherein one end of the stub is connected at the opened end of the slot by using the connection part.

4. The slot antenna according to claim **1**, wherein one end of the stub is connected to the first long side of the slot by using the connection part,
- another end of the stub is connected to the second long side of the slot by using an other connection part, and
- the connection part is connected on an opened end side with respect to the other connection part.

5. The slot antenna according to claim **4**, wherein a length of the stub is longer than one quarter of a wavelength corresponding to a used frequency and shorter than one half of the wavelength.

6. The slot antenna according to claim **1**, wherein a plurality of stubs are disposed inside the slot.

7. The slot antenna according to claim **6**, wherein the stub is disposed at a position a predetermined distance away from the opened end of the slot, the predetermined distance being n/2 times (n is integer) as long as a wavelength corresponding to a used frequency.

8. The slot antenna according to claim **1**, wherein the feeder comprises a coaxial cable, a coplanar type feeder, or a micro-strip type feeder.

9. The slot antenna according to claim **1**, wherein the connection part and the stub are integrally formed with a printed-circuit board formed on the conductor surface.

10. The slot antenna according to claim **1**, wherein the stub extends from the connection part in a lengthwise direction which is substantially parallel to the first and second long sides of the slot.

11. The slot antenna according to claim **1**, wherein the stub comprises a plate-shaped member.

12. The slot antenna according to claim **1**, wherein the conductor surface comprises a rectangular-shaped conductor surface including first and second long sides, and a short side which includes the opened end of the rectangular-shaped slot.

13. The slot antenna according to claim **12**, wherein the first and second long sides of the slot are substantially parallel to the first and second long sides of the conductor surface.

14. The slot antenna according to claim **12**, wherein the connection part extends in a lengthwise direction which is substantially parallel to the short side of the conductor surface.

15. A slot antenna comprising:

a conductor formed on a substrate;

a rectangular-shaped slot formed in the conductor and including first and second long sides, and a short side comprising an opening at an edge of the conductor surface;

a stub formed inside the slot;

a connection part connected to the stub and connected perpendicularly to the first long side of the slot; and

a feeder connected to the conductor on the first and second long sides of the slot such that the feeder is connected across the slot,

wherein a length of the connection part is greater than a perpendicular distance between the second long side and the stub.

* * * * *